Thermal Processing of Foods
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Lecture 2
Blanching, Pasteurization, Ultra-pasteurization, Hot fill and UHT

Good afternoon everybody. So today's lecture is about blanching, pasteurization, ultra-pasteurization, hot fill and UHT.

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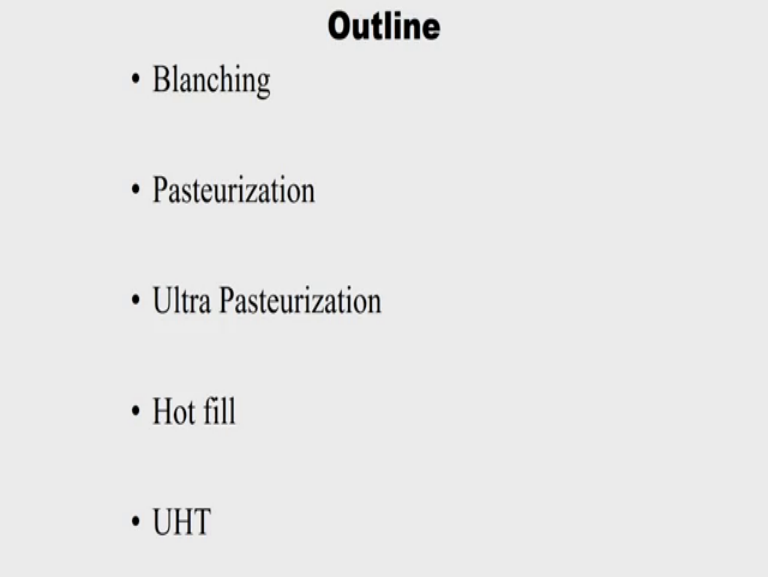

The outline goes like this blanching, pasteurization, ultra- pasteurization, hot fill and UHT and the equipments wherein these operations are being carried out also we are going to discuss.

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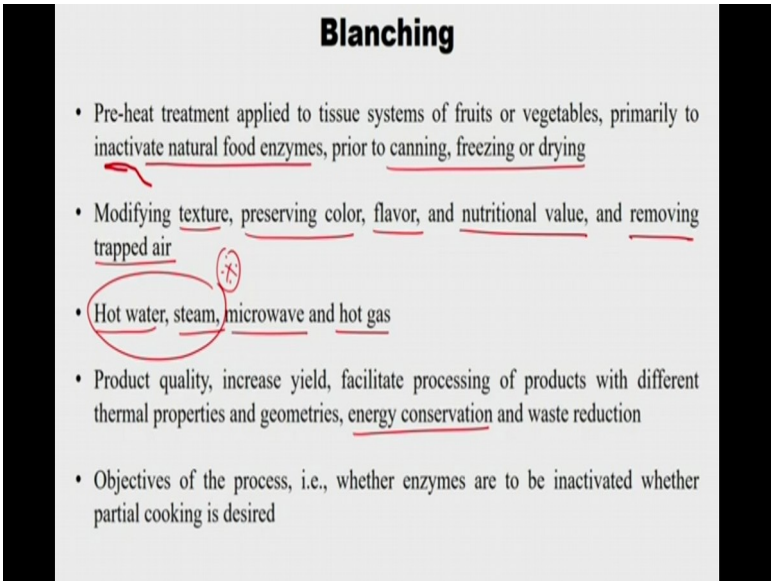

The first one is blanching. The blanching is the process where pre-heat treatment applied to tissue systems of the fruits or vegetables primarily to inactivate natural food enzymes. So this is very important that in this process we are not going to kill any microorganism. It is a pre-heat thermal treatment so which inactivates natural food enzymes, prior to canning, freezing or drying. So these are all the operations thermal processing operations. So before that it is a pre-heat treatment which is done on the mostly on vegetables and sometimes on fruits also we used to blanch.

Actually apart from inactivate natural food enzymes we also do this operation to modify texture of the food and preserving its color, flavor and sometimes nutritional value, removing trapped air. So for all these purposes also blanching can be done. So, the blanching medium are hot water, steam, microwave or hot gases. So, mostly the hot water and steam are in practice nowadays in the industries.

Actually apart from these apart from inactivate natural food enzymes, so it also yields good product food quality and it increases the yield. Sometimes it facilitate the processing of products with different thermal properties and geometries and energy conservation and waste reduction.

So instead of directly going for sterilization or canning operations, so if we blanch then for example if we wanted to tell. During the canning operation blanching removes the trapped air and also sometimes in the peeling it aces the operation of peeling the vegetables. So, it it also

conserves the energy which is done on normal thermal process. The objective of the process is twofold either the enzymes are to be inactivated or sometimes when partial cooking is desired that time also blanching can be done.

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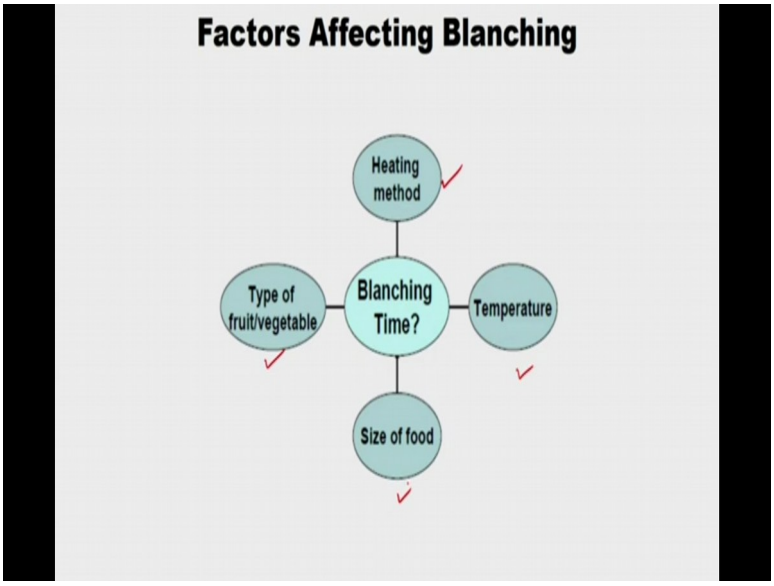

So what are all the factors affecting blanching are the types of fruits or vegetables what we use and the heating method. Heating method in the sense, whether we use steam or hot water or microwave or hot gases. So based on that also your blanching operation will be affected and the temperature at which the blanching operation is being done and the size of the food also matters when we fix the blanching time.

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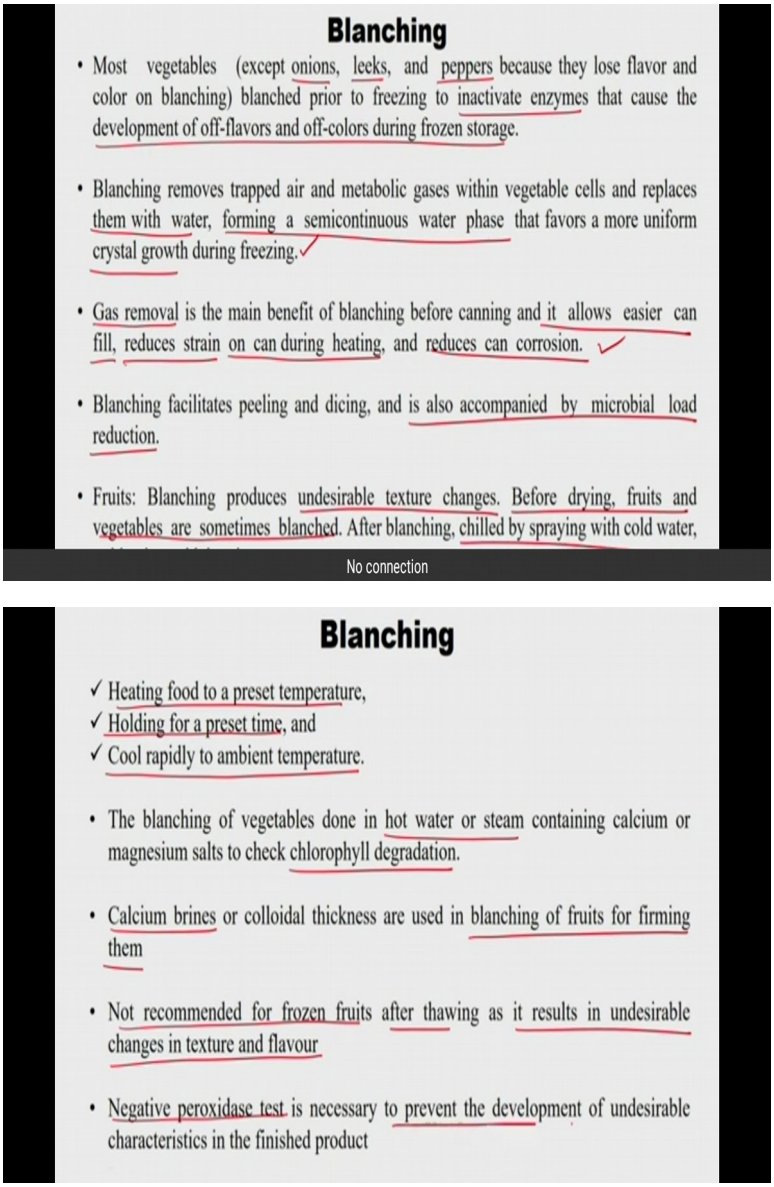

Actually most of the vegetables require this blanching operation prior to freezing to inactivate the enzymes but certain vegetables they do not require the blanching operation which are all onions, leeks and peppers. So because when you do blanching what happens is they lose the flavor and color during blanching operation and actually if the blanching is not being done then the enzymes will be activated and which causes the development of off-flavors and off-colors during frozen stage.

So when we go for freezing the vegetables so it causes the off-flavors and sometimes off-colors also. So because of that normally blanching is done on the vegetables except few. And blanching

also removes trapped air and metabolic gases within vegetable cells and replaces them with water, which forms a semi-continuous water phase during freezing stage. Actually when we freeze if there is a trapped air it causes some of the off-flavor or off-color so when we do the blanching it removes the trapped air inside the vegetable cells and also it soften the vegetable and it forms the semi-continuous water phase which favors the more uniform crystal growth during freezing operation.

So we already told it is done before freezing or canning or drying. So why it is being done before freezing is because of this reason and the second on canning why it is being done. The canning also same the gas removal which benefits the blanching before canning and also it allows easier can fill because I already told it softens the vegetables, so we can fill the can easily and also reduces strain on can during heating also and reduces the can corrosion.

Can corrosion which happens due to the trapped oxygen so when you do the blanching it removes all the gases so that the oxygen removal further reduces the corrosion on the canning and also blanching facilitates peeling and dicing and is also accompanied by a microbial load reduction. For example, while peeling and dicing so this operation we will see in subsequent lectures. So the peeling is nothing but removal of the skin of your skin of the vegetables and dicing is size reduction. So, based on the size we wanted the vegetables to be so the dicing operation is being done. So, this time when we do the blanching we accompanied the load reduction so that means the soil microorganisms will be removed during blanching operation when we are doing during the peeling or dicing operations.

Usually fruits, the blanching is not required because in fruits blanching produces undesirable texture changes. But sometimes what happens is in fruits the mild blanching treatment is being done very very few seconds and before drying, fruits and vegetables are sometimes blanched. So before going for drying operations.

So, we have seen 3 operations, one is before during freezing and before during canning and sometimes before drying of fruits and vegetables we do the blanching operation but normally in fruit it is undesirable because which causes the texture changes. After blanching, normally it should be sprayed with the cold water or blowing dry air then it has to come to the normal atmospheric temperature.

Actually what are all the thermal operations being done during blanching is first we need to heat the food to the preset temperature then holding for some time, required time at the preset temperature then cool rapidly to the ambient temperature. Actually most of the time we use hot water or steam. Sometimes what happens is we do this this operation with the calcium or magnesium salts to check the chlorophyll degradation.

So this chlorophyll enzyme degradation. So instead of your hot water or steam so we do it with a calcium or magnesium salts. And also the calcium brines are used in blanching fruits for firming them. So if you want to firm the fruits, I already told fruits normally we do not do but if at all we do it is a with mild temperature in very few seconds. So at that time we use calcium brines to firm the fruits. For not recommended for frozen fruits after thawing because it results undesirable changes in the texture and flavor.

Actually the correct time and temperature we set based on the negative peroxide test. So the peroxide is the enzyme. So if there is no peroxide present in that food products or vegetables food products here vegetables or fruits so that means that is it required temperature and time for the blanching operation. So which is necessary negative peroxide test is necessary to prevent the development of undesirable characteristics in the finished products. If there is no peroxide so that means the blanching is done at correct time and temperature.

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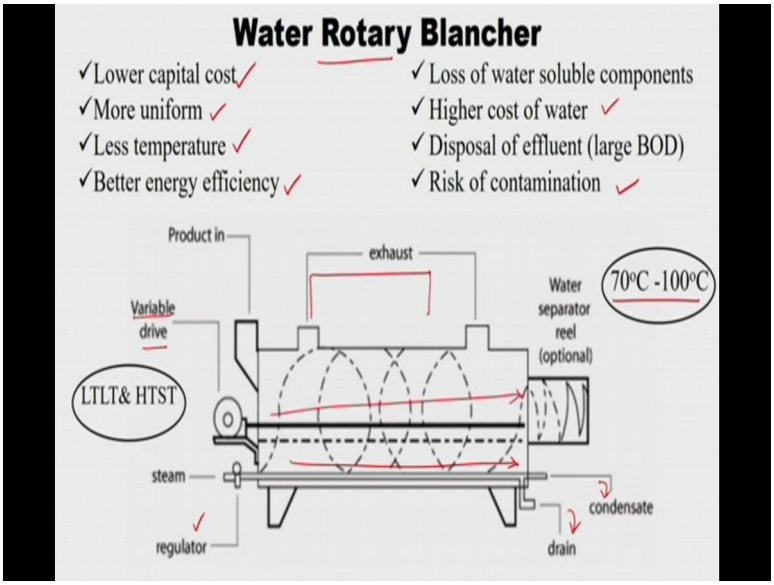

Usually we already told the heating medium can be of steam or hot water or microwave or hot gases. So normally steam and water is being used extensively. So there are two types of blanches one is water rotary blancher, rotary also specific so we will discuss and another one is steam blancher. The water rotary blancher, this is the diagram so normally the temperature is 70 to 100 degree centigrade. So there are two process being applied in the blanches one is LTLT, so that means low temperature less time process low temperature less time process and sometimes it is done at high temperature short, short time process as well.

The water blancher can be of two types; one is rotary blancher another one is the chain or belt conveyor is used to convey the product from the inlet to outlet. So here we are going to discuss about the water rotary blancher. So here is the variable drive so with which the product is being fed into the blancher. So this is the water level the hot water level is being maintained when the blancher rotates, so your product also rotates and it is being carried to the end of the blancher.

So, when it rotates so it immerse in the hot water then goes above, then goes above, then that is the way it is being carried out to the end of the blancher and also sometimes steam is also used to heat the water but here the steam is indirectly heats the water but it is it is need not to be of food quality because it is not directly involved in the heating of the food products. This is the heat and this is steam, steam is being fed here to maintain the temperature of the hot water and condensate is removed here and this is the drying wall and this is the regulator for the steam so this is these two are exhaust. So, here this variable drive is used to rotate the blancher. So, here the product is being fed and here we remove the product.

So the advantages side, it is of lower capital cost and we get more uniform temperature in the food products and less temperature is needed we normally go for water blancher and better energy efficiency for the energy being used. But disadvantages side we are losing lot of water soluble components and higher cost of water because we cannot reuse the water because already we told before that itself.

So it sometimes reduces the microbial load as well. Some soil microorganisms also will be there in the used water so we cannot reuse the water again and again. So every time we need to use the fresh water so higher cost of water and the disposal of effluents. So in the effluent you will have large BOD so we will be facing problem in disposing it and risk of contamination so because

your effluent has already microorganisms. So that may cause contamination as well as in the food products.

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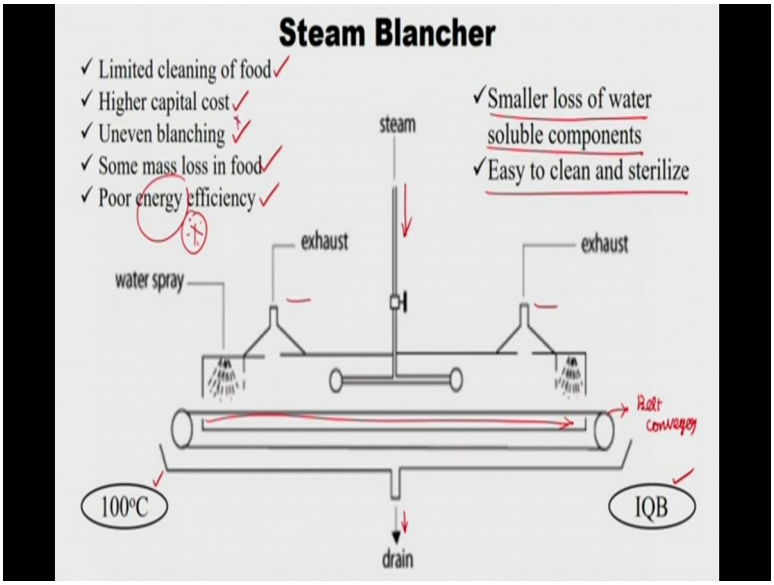

The second one is steam blancher. So here it is a variable drive. So this is rotary blancher so the same can be replaced by the screw or belt conveyor, so through which your product will be conveyed from the into out. So that also can be done. So that is nothing but water screw blancher. So, what we have seen here is a water rotary blancher and the steam blancher so this is the way steam being fed and these two are exhausts and sometimes hot water spray also be used along with the steam and this is the belt conveyor.

Here is the belt conveyor so through which your product is conveyed from inlet to outlet. So this drains the condensate as well as the hot water so this is the drain here in the special tree. In the steam blancher when compared to water blancher it has smaller loss of water soluble components and easy to clean and sterile because it has there you have variable driving mechanism. Here it is only one belt and some steam sparger only there. So it is comparatively it is easy to clean and sterile and advantages wise, these two and disadvantages wise limited cleaning of the food. Limited cleaning in the sense, for example, if we use leafy vegetables here in the steam blancher so what happens is, during blanching it forms the matte kind of thing. So then it reduces the heat transfer further inside the cold part of the product.

So it is not only limited cleaning and also sometimes what happens because it forms the matte you also we also have un-uniform temperature distribution and higher capital cost when because steam is being used and uneven blanching we already told because not only uneven blanching when compared to no blanching uneven blanching is bit dangerous because sometimes you will have also contaminations. So uneven blanching due to uneven temperature distribution because your heat transfer coefficient is decreasing and some mass loss in the food also cannot be avoided and poor energy efficiency.

Poor energy efficiency in the sense for the heating medium what we use, it will give less efficiency when compared to water blancher and the temperature is almost 100 degree centigrade and this poor energy efficiency can be taken care if we use the recirculation of steam so that we will see and there is something called IQB. So this is nothing but individual quick blanching. So here what we do is we take only one layer of the food product, so so that each food product will have direct contact with the steam. So the energy efficiency or uneven blanching can be improved using IQB and otherwise we also told about that recirculation of steam so that way also we can improve the energy efficiency of the steam blancher.

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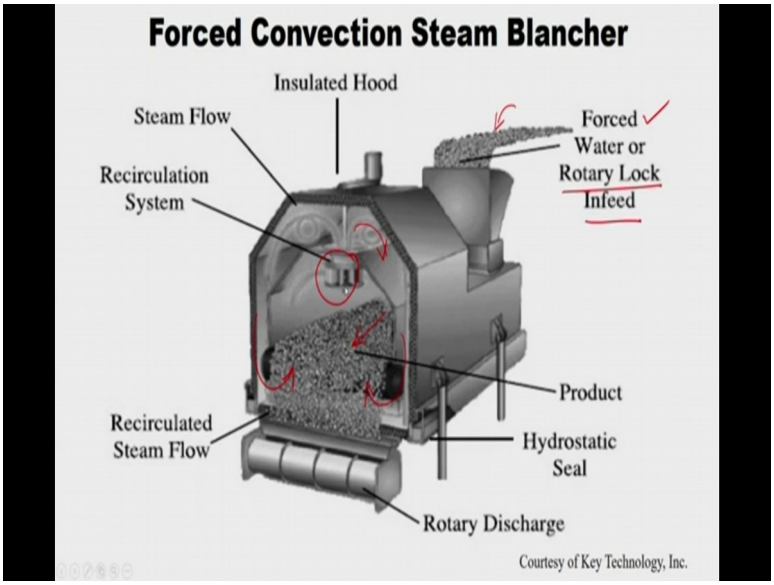

So here if you see this is the variable drive here, so through which your product is being fed so here your rotary lock infeed, so your product is fed and here it is taken out and we use forced water, forced water or rotary lock infeed so through which your product is being fed and if you

see here, so here we have a recirculation system. So your steam is being recirculated, so that it will have the what is it the temperature distribution is even not only for that and temperature distribution will be uniform and we have even blanching. So for that reason the recirculation of steam and also it improves the energy efficiency. Recirculation system, so this is the way the steam is being recirculated to the product as well. Forced convection, so the recirculation system will have fan mechanism the forced convection so that the steam is distributed in all all parts of the blancher.

So the next one is pasteurization. So in the blanching what we have since it is been employed to vegetables or fruits. Fruits normally we do not employee blanching because it offers the off-flavors and off-colors and sometimes before drying blanching process is applied to the fruits as well. So this process of blanching operation is being done before canning or before freezing or before drying. So mostly it is done to inactivate the enzymes or sometimes it is also done to remove the gases which further causes the corrosion and undesired flavors in the canning or drying operations and there are two major mediums is being used in the blanching operation.

One is steam other one is hot water. So they are based on that there are two types of blanches. One is hot water blancher and steam blancher. So either rotary mechanism is used or belt or screw conveyor is used to convey the product from into out and sometimes forced circulation is also used in the steam blancher to increase the energy efficiency and each blancher each blanching mechanism have its own advantages and disadvantages. It is we supposed to select which time temperature combinations and which type of heating medium we wanted to use during blanching operations. So normally water blancher is used for 70 to 100 and steam blancher is used for 100 degree centigrade.

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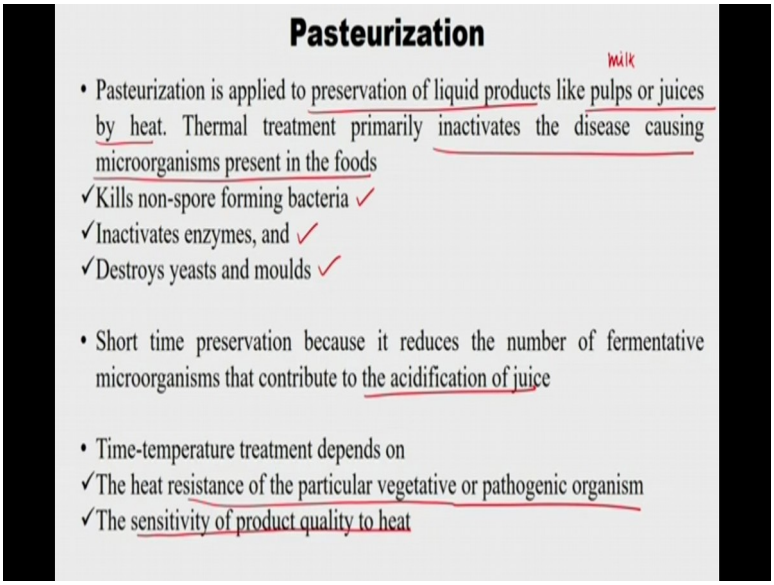

So the next one is pasteurization. So pasteurization is applied for preservation of liquid products like pulps or juices by heat and most one one I must is the milk. So milk pasteurization is very much normal. Thermal treatment primarily inactivates the disease causing microorganisms present in the foods. They be just to activate the food and enzymes in blanching operation but here it also inactivates disease causing microorganisms presents in the food. So it kills non-spore forming bacteria, the spore forming we are supposed to go to sterilization. It it also inactivates the enzymes and it destroyed yeasts and molds. Short time preservation because it reduces the number of fermentative organisms that contribute acidification of juice.

So, it is not a long time preservation technique pasteurization because it only reduces the fermentative microorganisms that what we call it as a non-spore forming. This this contributes, if we have fermentative microorganisms this becomes acidification of juice that is where if we keep milk without heating it so then the milk goes waste. So, the acidification occurs over there due to fermentative microorganisms and the time temperature for the pasteurization depends upon the heat resistance of the particular vegetative or pathogenic organisms because the pasteurization is done to kill the non spore forming so the temperature and time should be enough to kill them and also the sensitivity of the product quality to the heat and also you should not harm the record enzymes in the food products. So these two are based on which the time temperature combination should be fixed for pasteurization.

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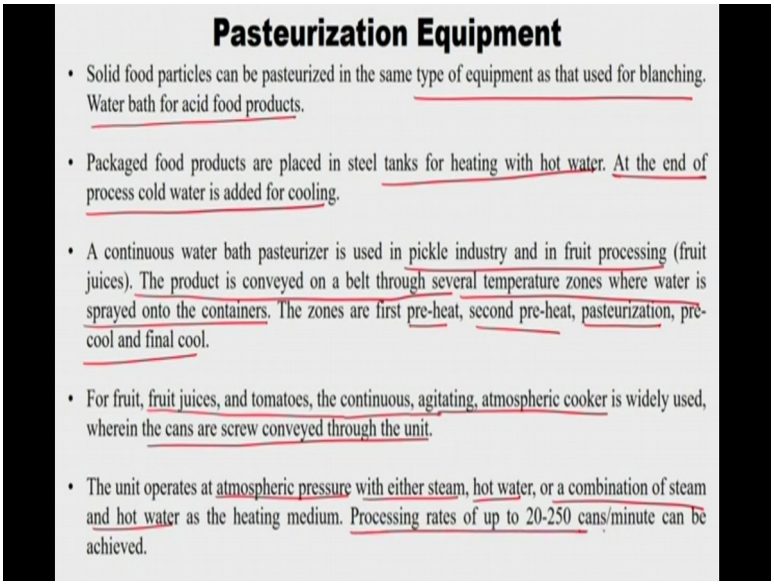

So normally solid food particles can be pasteurized in the same type of equipment used for blanching. So we can use any one of the blanchers for pasteurizing solid food particles and usually acid food products are used are pasteurized using water bath and packaged food products are placed in steel tanks for heating with hot water. So if it is a packaged food products we need a separate tank so in which they are pasteurized using hot water. At the end of the every process the cold water is added for cooling. Either blanching also we have seen finally it has to be cooled to the atmospheric temperature. Here in pasteurization also same thing has been done and continuous water bath pasteurizer is used in pickle and food processing industries mostly in fruit juices. The product is conveyed on a belt through a several temperature zones where water is sprayed onto the containers.

The zone is first to pre-heat then second pre-heat then pasteurization then pre-cool and final cool. So there we have also seen in blanching also it is heated to the preset temperature then holded then cooled. So here in pasteurization can be done in different ways. If it is a solid food particles it can be done in blancher as well and if it is for food acid food products because there you do not require the low acid food products only we need to bit take care because the sea bought us some microorganism which is a toxin. So normal acid food products we can do it in water bath

itself. So if it is a packaged food products then it is done in the steel cans using hot water and if it is a fruit products or pickle then that is done in the continuous water bath pasteurizer.

So usually what we have seen in the blanching operation same way the products are being conveyed through the belt conveyor or screw conveyor. Then after the heat treatment, the food products to be cooled to atmospheric temperature. Usually the fruit juices, tomatoes are pasteurized using continuous agitating atmospheric cooker. Cooker is also a pasteurizing equipment and wherein cans are screw conveyed through the unit. So we already have seen here the continuous water bath pasteurizer. So, if it is a canning products that is packaged food products that is screw conveyed through the unit.

Usually the unit operates at atmospheric pressure with either steam, hot water or a combination of steam and hot water. As the heating medium processing rates are up to 20 to 250 cans per minute is achieved in the pasteurization. So usually sterilization is done in normal atmospheric pressure as well as well as the higher pressure but here pasteurization we have already told it is a mild treatment about the blanching and below the sterilization because the food products which are pasteurized cannot be stored in normal atmosphere temperature. It has to be stored in the refrigeration's temperature. So in that case mostly the steam or hot water with atmospheric pressure only used as a heating medium. So normally if it is can those have to be pasteurized so normally process is 20 to 250 cans per minute.

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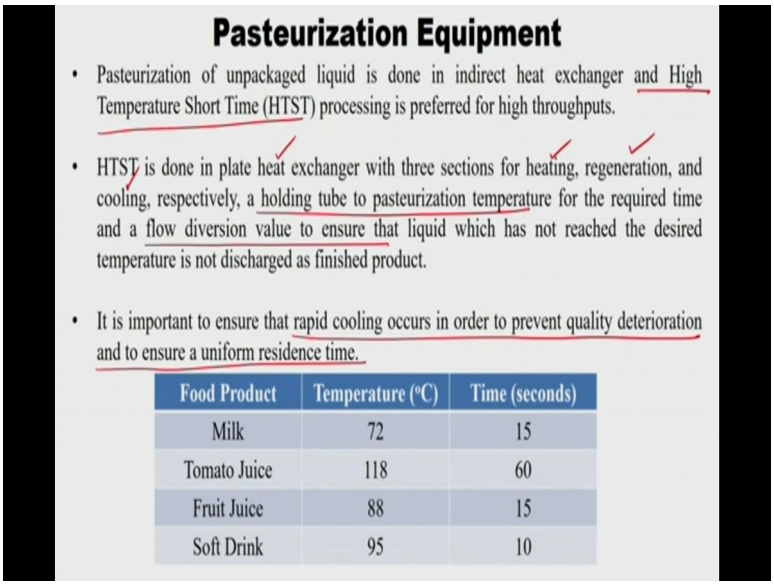

The pasteurization of unpackaged liquid is done in indirect heat exchanger and with using high temperature short time processing. So this is unpackaged liquid, liquid products. So it is done in the continuous pasteurizer using high temperature short time processing and HTST is also done in plate heat exchanger. So which has three sections one is heating, the second one is regeneration and cooling. So the heating we use fresh heating medium. In regeneration the pasteurized food product itself will lose its heats with the fresh product. Then cooling is done using separate cooling medium.

Then there is a holding tube to keep the product at the particular temperature for the required time and there is a flow diversion wall which ensures if the food product or liquid food product here is not reached to the particular temperature and holded it for particular time then it divert back the unpasteurized product into the raw milk product or raw liquid food product. And it is important to ensure that rapid cooling occurs in order to prevent quality deterioration and ensure uniform residence time. So here immediately the cooling has to be started because already we holded it for particular seconds so even if we delay the cooling process then there may be a quality deterioration.

So we have to strictly maintain the time temperature combination as well once the product comes out of the holding tube it has to be cooled immediately. So there are certain food products and time temperature combination is given as an example anyway we will see in detail. There is a one particular lecture on pasteurization. So there we will see in detail about what are all the time temperature combination for various food products here is an example for milk it is 72 degree centigrade for 15 seconds, for tomato juice is 118 degree centigrade per 60 second, fruit juice 88 degree centigrade for 15 seconds and soft drink 95 degree centigrade for about 10 seconds.

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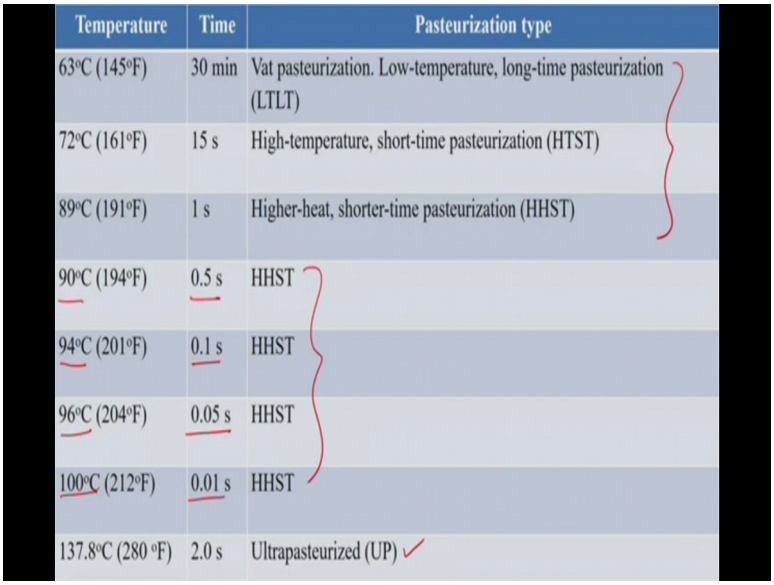

Temperature	Time	Pasteurization type
63°C (145°F)	30 min	Vat pasteurization. Low-temperature, long-time pasteurization (LTLT)
72°C (161°F)	15 s	High-temperature, short-time pasteurization (HTST)
89°C (191°F)	1 s	Higher-heat, shorter-time pasteurization (HHST)
90°C (194°F)	0.5 s	HHST
94°C (201°F)	0.1 s	HHST
96°C (204°F)	0.05 s	HHST
100°C (212°F)	0.01 s	HHST
137.8°C (280 °F)	2.0 s	Ultrapasteurized (UP)

So this is based on the time temperature combination. So what are all the pasteurization types. So 63 degree centigrade if you hold it for 30 minutes this is called (vas) vat pasteurization. So this is nothing but a batch process so it is a low temperature process but long time so we call it is a LTLT. Then 72 degree for 15 seconds. It is a high temperature short time pasteurization process HTST. Then 89 degree centigrade for about 1 second that is nothing but higher heat shorter time pasteurization that is HHST. So all three are being done for only milk and there are HHST process for various time-temperature combination. So if it is 90 degree it is done in point 5 seconds. If its 94 it is point 1 second if it is 96 it is point point 05 second if is 100 degrees then point 01. So all are HHST process and if the temperature is 137 point 8 degree centigrade of about 2 seconds, so that is nothing but ultra-pasteurized milk that is called UP. So this is it, high temperature and about 2 seconds.

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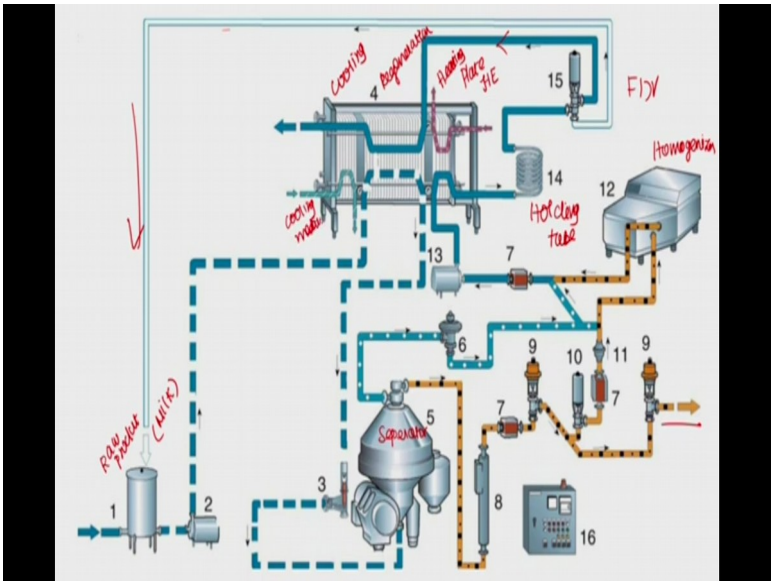

So this is the continuous pasteurizer as I told already. So we will see in detail in the milk pasteurization lecture module but here I am going to give a glimpse of that. So this is my raw product. So this is nothing but here it is a milk. So it is pumped in through the feed pump and it goes here. So this is nothing but a plate heat exchanger. So as we told it has three sections. So one is heating section. This is regeneration section. So this is cooling section, okay. So the raw product is being pumped and goes to regeneration section so in the regeneration section this is nothing but a pasteurized milk. So that gives away its heat then after getting pre-heated the raw milk comes here and it goes to the separator.

So this is the separator. So which separates the cream milk as well as the skimmed milk. So if you need cream milk separately you can take it out here or if you need both your skimmed milk as well as cream milk then cream milk goes here and homogenizer. This is a homogenizer so it is getting homogenized and again it mixes with the skimmed milk then it is pumped and it goes to sorry this is heating section. So this is heating section, this is cooling section.

So in the separator your cream milk and skimmed milk is separated so if then it is fed back to the homogenizer. From the homogenizer it is pumped and it goes to heating section of the plate heat exchanger so there it is heated to the required temperature for example 72 degree for HTST process. So then it is this is the holding tube. So it is hold for about 2 seconds then it goes to, the this is nothing but a FDV flow diversion valve.

So it checks whether the pasteurized control is done, the 72 degree, 2 seconds is done, so here the check is there. So if it is unpasteurized it sends back to the raw feed tank or if it is pasteurized then it goes to regeneration section where it gives its heat to the raw milk then it goes to cooling section where it is cooled to the atmospheric temperature. So this is cooling medium, separate cooling medium and this is separate hot medium, so either steam or water. So, this is normally this is normal continuous pasteurizer, continuous flow pasteurizer.

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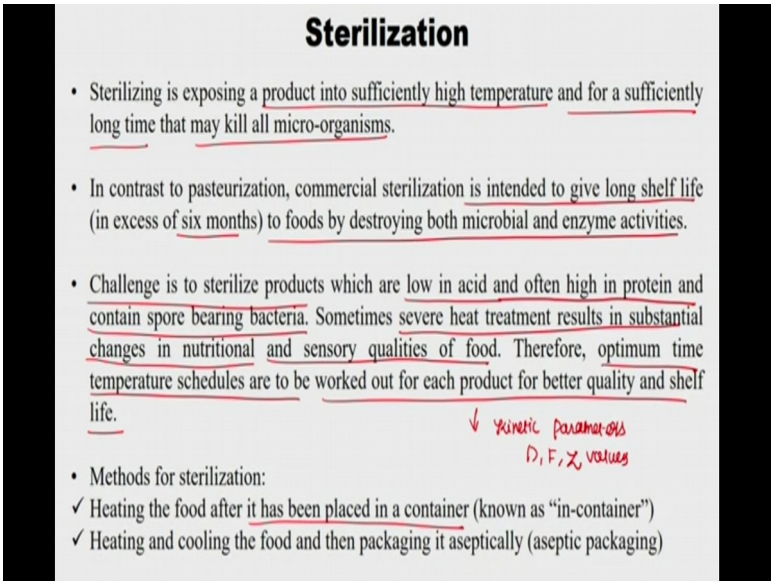

So next one is sterilization. Though it is not told your UHT comes under sterilization. The sterilization is about the pasteurization because the pasteurization I already told we cannot store the finished product in the normal atmospheric temperature but sterilization that is not needed. Sterilizing is exposing a product into sufficiently high temperature and for a sufficiently long time that may kill all microorganisms. In contrast to pasteurization intended to the sterilization is intended to give long shelf life.

So it is about 6 months period to foods by destroying both microbial as well as enzyme activities. So there we told we will not be able to remove the spore forming microorganism. So only we can kill non spore forming microorganisms in the pasteurizer but here in the sterilization we will be able to kill the both microbial and enzyme activities. Actually the challenge is normally done in low in acid and often high in protein containing spore forming bacteria. As I already told the acid

foods we need not bother about but low acid food is very much favorable for the C.bot which produces the toxin.

So at the same time those low in acid foods are often high in protein. So we need to fix the time temperature combination which kills the spore forming microorganism as well as it also has to retain high protein content. So that is where the challenge is. Sometimes severe heat treatment results in substantial changes in nutritional and sensory qualities of the food that we need to take care. Therefore, optimum time temperature schedules are to be worked out for each product for better quality and shelf life. So this we are going to discuss in kinetic parameters. There are D, F value and Z values have to be found out to find optimal time temperature combination for killing the spore forming microorganism in low acid food as well as to maintain the high protein or any nutritional contents.

The methods of sterilization, heating the food after it has been placed in a container. So this we call it is known as “in-container” or retort retorting we call it as and here we call the heating the food after it has been placed in the container. So first food is filled in the containers, the containers are being sterilized. So we call it is as a “in-container” or retorting and heating and cooling the food and then packaging it aseptically. So this is we sterilize the food separately and sterilize the package separately and also we maintain aseptic environment to fill the sterilized product in the sterilized packaging. So that is nothing but a aseptic packaging.

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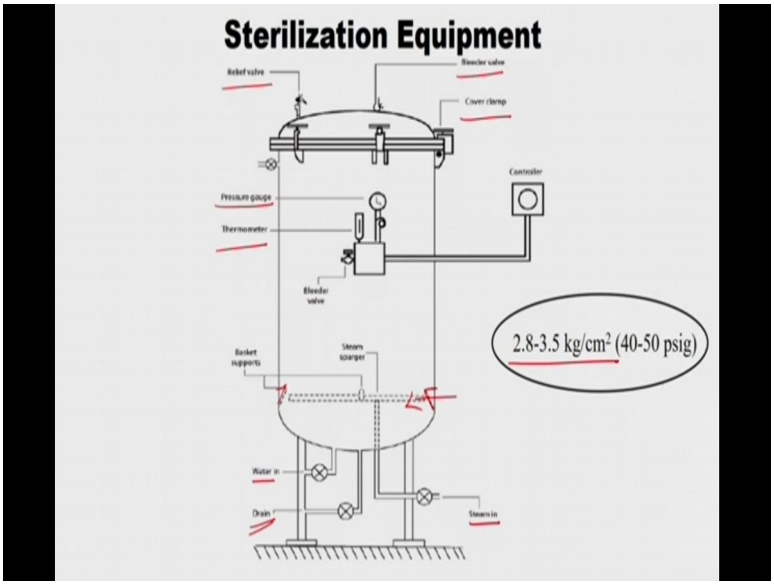

So sterilization equipment is this is the retort so normally which operates in the pressure of 2 point 8 to 3 point 5 kg per centimeter square it is around 40 to 50 psig. I have already told the pasteurization normally done in atmospheric temperature but for sterilization you need most of the time higher pressure. So this is the normal batch retort. So here you have a cover clamp, then this is a bleeder valve, this is relief valve and here you have a control mechanism which measures the pressure as well as the thermometer maintains the temperature and here also you have one more bleeder valve.

So this is the spargers, steam sparger where your steam is being fed into the retort and this is a basket supports where here only you will stack the can. So this is retorting process. So already you have a food filled can. So the cans are being stacked in the basket support.So this is a steam sparger your steam in and apart from that you have a hot water also sometimes it is not hot water it is water in to immediately cool. So what we told his first the cans are being stacked that then after that the steam is on.

There is a come a period to reach the product into steam temperature. Then it is heated to the particular time temperature combination. So once it is kept at particular time temperature combination then immediately it will be cooled. So at the time the water is being used. So this is that drain after the steam is condensed the condensate will leave as well as the cold water which is used as a cooling medium also will drain through this.

And here certain things we need to remember is, the thing is when you are using the steam you are the can pressure inside pressure as well as the outside pressure of the steam will be almost balanced during heating stage but when it comes to cooling immediately it starts cooling. The outside temperature drops down and can inside pressure is high. So to balance that pressure imbalance we also send compressed air and before that the purging also done.

Purging in the sense so we we need to remove the trapped air in between the cans because they are very dangerous agents because the air heat transfer coefficient is very less. So during sterilization you will have temperature gradients. So when the steam is on it will be high velocity to remove the all trapped gases. Then after that it is heated to the particular time temperature combination. Then while cooling we use compressed to balance the pressure then finally cooling is done and your products are sterilized.

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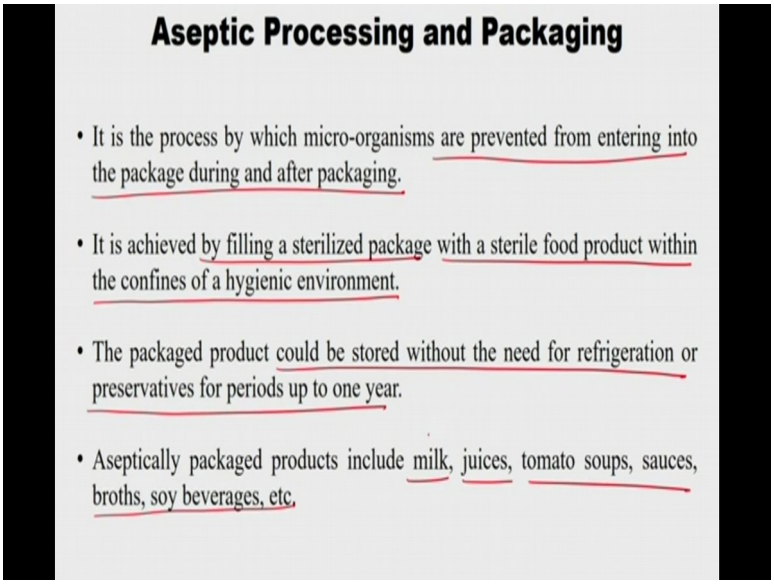

Then aseptic processing and packaging. So in this process by which microorganisms are prevented from entering into the packaging and during and after packaging. So you sterilize the packaging separately and also you sterilize the food separately and maintain the aseptic environment to fill the packaging. So normally there won't be any contamination of microorganism before and after packaging. It is achieved by filling sterilized to product the sterilized food product within the confines of the hygienic environment.

So this is aseptic environment. The packaged product could be stored without the need of refrigeration or preservatives for periods up to 1 year. So we can store these products aseptic processing products with almost up to 1 year so without any refrigeration or preservatives. Aseptically packaged products include milk, juices, tomato soup, sauce and broths, soy beverages, etc. So this milk I have already told it can pasteurized as well sterilized as well aseptic processing as well.

So it is nothing but a shelf life, so how much you want. So based on that your thermal processing for each product differs. So this is finite like aseptic process is done separately for packaging separately for food product and the filling is also done in aseptic environment. So we do not need to store them in a refrigerating or environment or we do not need to use preservatives but here the problem is your nutrient quality. So that that you have to bit compensate because you will not get the same nutrient quality as you get in pasteurization.

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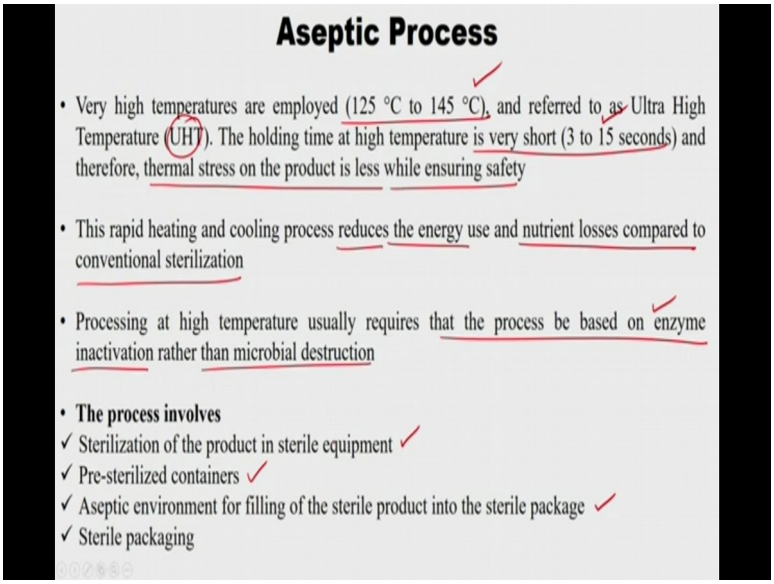

So the aseptic process is nothing but UHT. The very high temperatures are being employed almost 125 degree centigrade to 145 degree centigrade. So these are referred to ultra high temperature that is how it is called UHT. The holding time at high temperature is very short as I already told. If you keep it in very short time you can retain your nutritional qualities and also the thermal stress on the product is very less while ensuring the safety aspects as well. So this

rapid heating and cooling process reduces the energy used and nutrient losses compared to conventional sterilization.

So conventional sterilization is being done high time and bit lower compared to aseptic processing it is less temperature and high time process. So compared to that if you, we can reduce the energy uses as well as nutrient classes in the aseptic processing. So this is the process be based on enzyme inactivation rather than the microbial destruction. So this is we have already told to reduce the microbial destruction so the sterilization temperature itself enough. So that means around 121 degree itself enough but here we are doing it almost 125 to 145 above than the sterilization temperature because we are doing it for two reasons.

One is the energy use reduce the energy use and nutrient losses to reduce the nutrient losses but here our focus is time temperature combination should be decided based on enzyme inactivation because at this temperature definitely there there will be a microbial destruction so your time-temperature combination should be done based on the enzyme activation. So the more weightage to be given for the enzyme inactivation.

The process involved sterilization of the product in the sterile equipment and pre sterilized container and aseptic environment for filling sterile product into sterile packaging. The sterilization of food, sterilization of container and aseptic environment for filling the sterile product into the sterile packaging and finally the sterile package.

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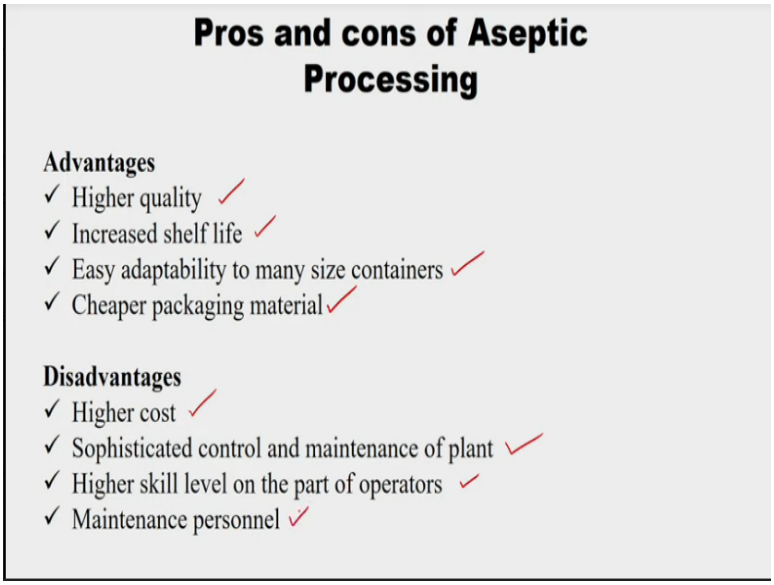

The pros and cons of aseptic process advantages high quality, we our shelf life is increase and easy adaptability to many size containers because there if you see the sterilization you are doing it in a closed retort so in sterilization so these are related to the food quality and shelf life right. So there are certain standards for equipments as well and operations as well there are rules and regulations being followed, even equipment manufacturing itself. So there if you use retorting so you need to use certain sizes of the cans only and certain amount of cans only. Any way we are going to see all those in canning operations.

So but here because it is a aseptic process your can is already sterilized and your food is already sterilized so you can have variety of cans from minimum size to maximum size. There is no restriction on, okay so the number of cans to be fed into the retorting equipment. So and one more is cheaper packaging material. Disadvantages high cost because we have to do two sterilization and also we need to maintain the whole plant as a aseptic, sophisticated control and maintenance of the plant in aseptic condition is very much disadvantageous one and higher skill level of on the part of operators even part-operators also to be high skilled and maintenance personnel all are disadvantages of aseptic processing.

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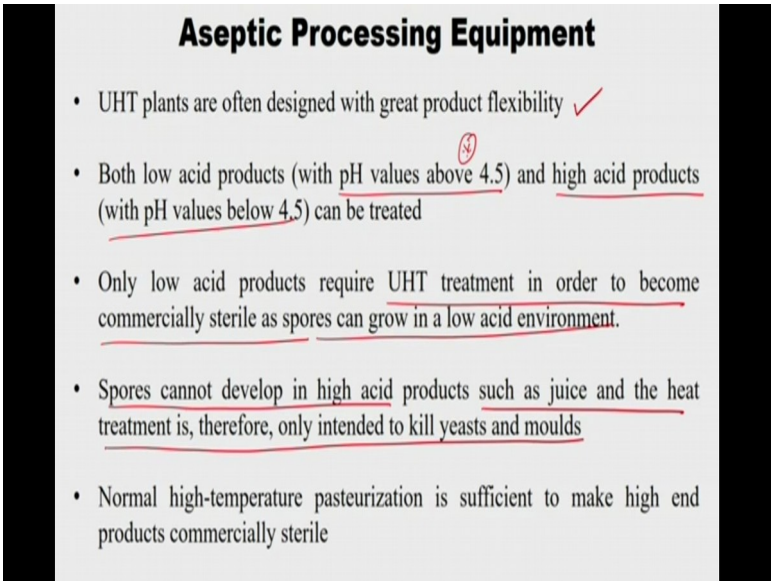

Usually UHT plants are often designed with greater product flexibility. Product flexibility in the sense, whether I can use both sterilization as well as aseptic processing in same equipment or not. So you need to have the product of, for example, if we want to use milk, fruit juices as well as tomato juices so I can use all the product in same equipment or not. So it is UHT plants are often designed with the greater product flexibility as well as the time temperature combinations. Both low acid products low acid products have pH values above 4 point 5 and high acid product so they these are below 4 point 5 can be treated in same UHT plant itself.

So why this discrimination, I already told the acid foods we do not have problem but low acid food so that gives the perfect environment for the spore microorganisms, spore forming microorganisms. So in that case we need to be bit careful about the low acid food. Only low acid products require UHT treatment, in order to become commercially sterile as spores can grow in low acid environment. So for example the plants are designed for both low acid and high acid. So the low acid only require UHT treatment but the high acid food we can employ the sterilization as well. Spores cannot develop in high acid product such as juice and the heat treatment is therefore only intended to kill yeasts and moulds.

So in that case I can maintain only sterilization temperature range only. So the normal high temperature pasteurization is sufficient to make high end products commercially sterile. So to sum up what it is being discussed here is UH plants are having various product flexibility as well

as various time temperature flexibility. So if it is a low acid food then we can use UHT treatment that is high temperature 125 to 145, 3 to 15 second. So if it is a high acid product then we can just go for normal high temperature pasteurization ultra-pasteurization or sterilization because there at that temperature in high acid foods there will not be any spore forming microorganisms.

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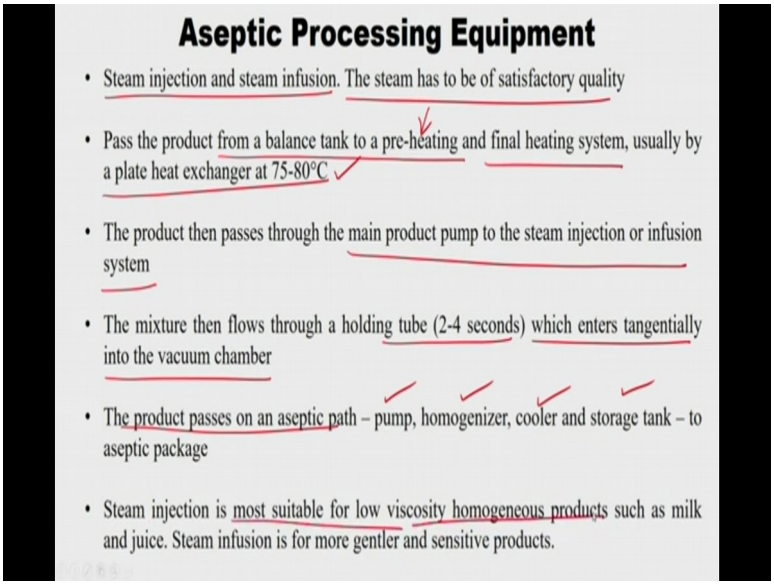

So then aseptic processing equipment. So this is there are two types of equipment because normally it is done in 125 to 145 so mostly the steam is used as heating medium and also here if we remember in blanchers, steam blanchers we also use steam to blanch the food products and there we need not have the food quality Steam. So it should not be of the satisfactory quality, it need not be of because the blanching is nothing but a preheat treatment. After that there is there are certain thermal processing that takes care of the killing of microorganisms because the blanching is done only for inactivate the enzymes, right.

But here the steam what is used is should be of satisfactory quality. So, that means it has to be prepared from the steam has to be from the drinking water. I mean high quality water, there should not be any a contamination and there are two techniques one is steam injection and steam infusion. Steam injection is nothing but your stream is injected into your products, food products. Steam infusion is your products are infused into the steam. There are two kinds of techniques are used and pass the product from a balance tank to preheating final heating system usually by a plate heat exchanger 75 to 80 degree.

So if you remember the continuous pasteurizing equipment the same thing being followed here. The preheating and final heating is done in the plate type heat exchanger so that takes care of 70 to 80 degree centigrade. So this is preheating, totally the preheating, final heating referred to UHT these both are heating only, preheating only. The product then passes through the main product pump to the steam injection or steam infusion system. Then after that the mixture then flows through the holding tube to hold that for 2 to 4 seconds and which enters tangentially into the vacuum chamber where your steam and product is being separated.

Then steam again comes here to pre-heat the raw food product. The product passes on an aseptic path that is pump homogenizer, cooler and storage tank to aseptic packaging. The steam is fed back to the plate heat exchangers where it used to pre-heat the product, preheat the raw food product. Steam injection is most suitable for low viscosity, homogeneous products. So that is nothing but injecting steam into the product such as milk and juice mostly steam injection would be used and steam infusion is for sensitive product. So which cannot be done by steam injection.

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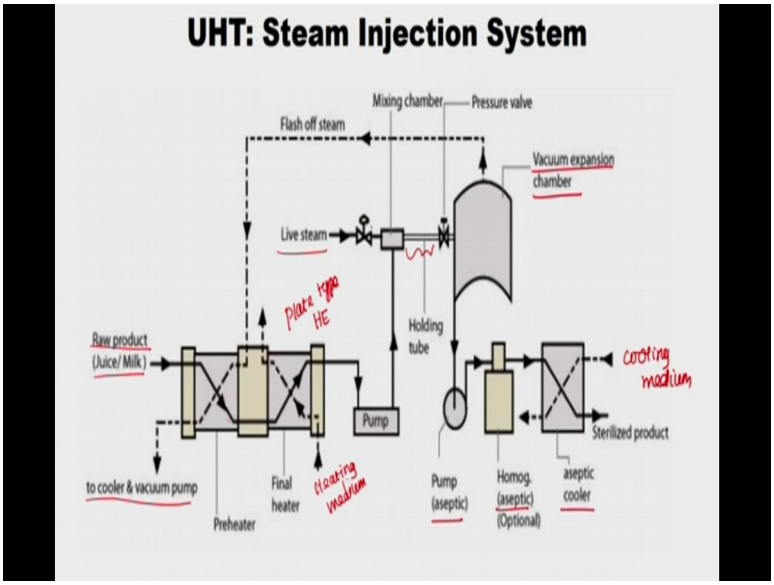

So this is steam injection system as I told already. So this is the vacuum expansion chamber where your steam as well as the product is being separated. It is flashed, your flash of steam comes here and fed into the plate heat exchanger system. This is the preheating your raw product whether juice or milk is first goes here so there your flashed steam heats and go to cooler and

vacuum pump but then your heated preheated raw product goes next section where it is heating medium is fresh heating medium is used, used to hit the raw product.

Then it is pumped and go to mixing chamber where live steam is injected into the product. Then this is the holding tube. It is holded it for particular time temperature combination then it is a pressure valve, then it goes to the vacuum expansion chamber, your flash of steam comes back to the plate type heat exchanger. So this is plate heat exchanger, plate type heat exchanger. Then your product, aseptic product, the ultra-high temperature product comes with the pump.

This is also aseptic, so all are aseptic, right, and there is homogenizer if you need. So there is a homogenization then after it goes to the cooler. The cooler also the cooling medium also the fresh one here so then the sterilized product goes for aseptic package. So the steam infusion system only this is different. This is different in the sense, there your product being fed into the steam column.

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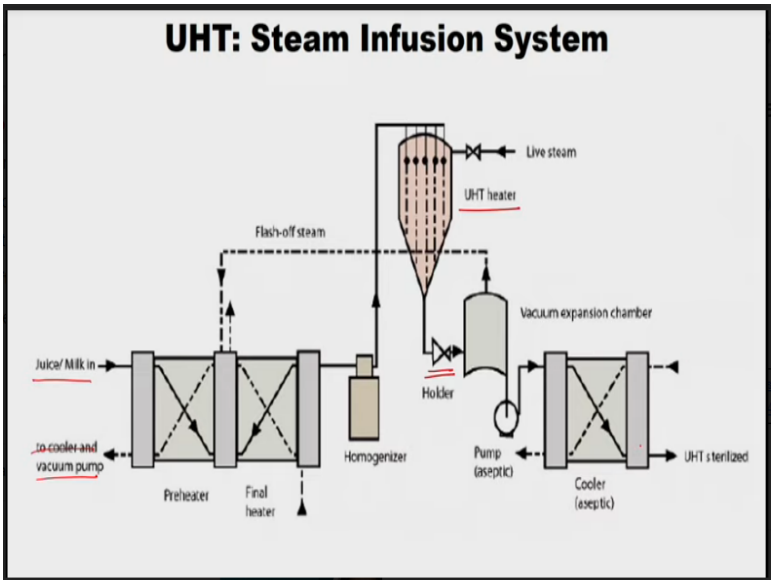

Here everything is same your milk is coming, your flash of steam and heating and the steam goes to cooler and vacuum pump and the pre-heating section it is heated by a steam and in the final heater we employ fresh heating medium and heat it. Then it goes to homogenizer, then the product is fed into the UHT heater fed into the steam. So then after that it is holder which holds for few seconds whatever required and it goes to vacuum expansion chamber where your flash of

steam comes back to the plate of heat exchanger and your product is pumped using aseptic pump and it goes to cooling section where fresh cooling medium is used to cool the product.

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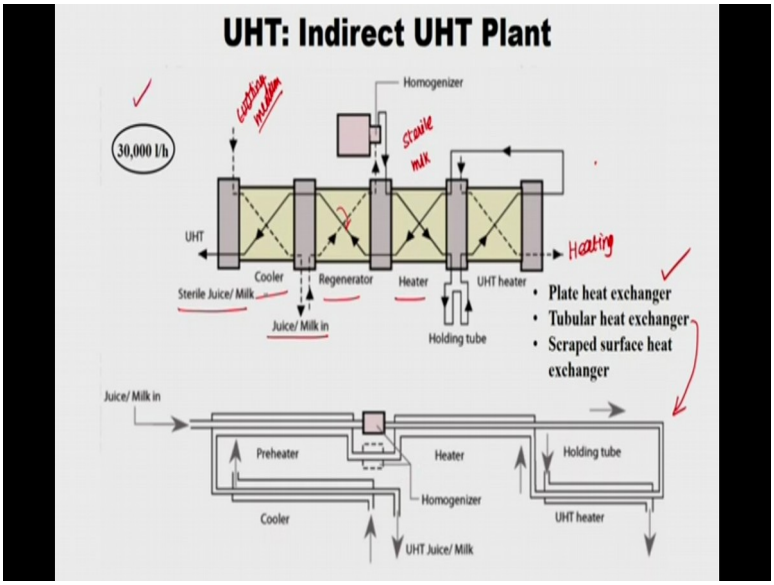

Apart from that these both are direct systems. Direct systems in the sense your steam as well as your product is directly mixing but here it is indirect. Indirect we have as we already discussed in the continuous pasteurizer we have a cooler, regenerator and heater. So what happen is your raw milk comes here so it is being heated by your, your raw milk comes and heated by your sterile juice so in for sterile juice or milk it is a cooler for raw milk it is a heater. Here the juice or milk is fed here and it goes to regenerator section. The regenerator section your sterile juice or milk is coming so it exchanges the heat between the sterile juice or milk and raw milk or juice.

Then after that it comes here in the cooler section. Cooler section your fresh cooling medium is employed to cool the sterile milk or juice. Then after that the raw juice is going to homogenizer. Then homogenized juice is coming in the heater. In the heater you will have again the sterile juice or milk, so there it is further heated. Then after that it goes to holding tube. Your so this solid line is your fresh, fresh or raw milk, raw milk or juice. The dashed lines are your raw milk or juice then your solid lines are nothing but your sterile milk. So first the raw milk is entering in the regeneration section. So it is going to the homogenizer, from the homogenizer the product is coming into the heater section, so where it is heated using the sterile milk or juice.

Then after that it goes to holding section where it is holded for particular seconds then it enters the ultra-heater. So where fresh heating medium is used to heat the already holded sterile milk or juice. Then after that it goes to the heater section. It goes through the heater section where it exchanges its heats with the raw sterile milk, then after that it goes to regeneration section then final cooler section your fresh cooling medium is used to cool the sterile milk or juice. So this is done in, this is plate heat exchanger. It is done in plate heat exchanger. The same thing can be done in tubular heat exchanger where your product is going in the inside tube and it is a homogenizer.

This is the pre heated section this is the heated section then after that it is holded for few seconds then after it comes back to the cooler section where fresh cooling medium is employed to cool the product. So it is done in plate heat exchanger, tubular heat exchanger or scraped surface heat exchanger. We have seen here the plate type heat exchanger as well as the tubular heat exchanger. Normally 30000 litre per hour is processed at indirectly using heat exchangers.

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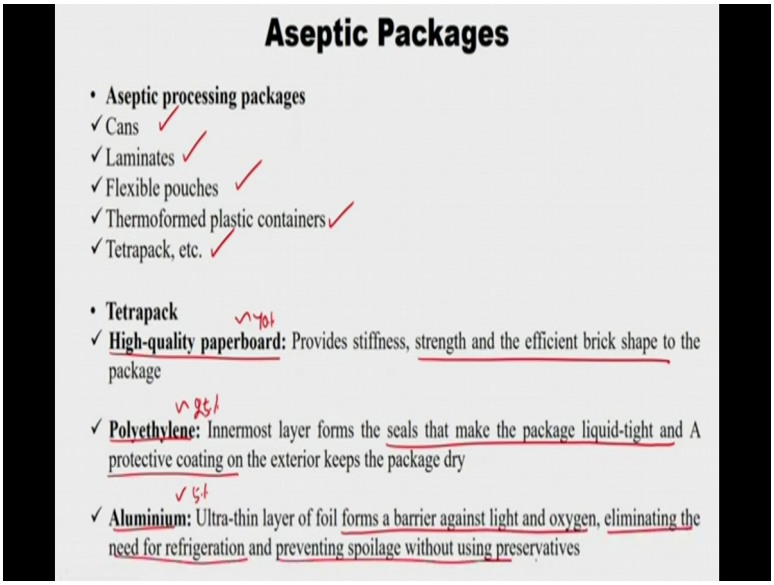

So the package is normally aseptic process packages, cans, laminates, flexible pouches and plastic containers, tetra packs all are aseptic packages. The tetra packs contains three components mainly, one is high quality paper board, so which gives the strength and brick shape to the packaging. The second one is polyethylene, so it seals the package, package liquid tightly, also it

gives the protective coating outside your packaging to be in dry condition and the third one is aluminium.

So this is almost 70 percentage is your paper boat, around 20 percentage is your polyethylene, around 5 percentage approximately is aluminium. So this layer foil forms a barrier against a light oxygen eliminating the need for refrigeration and preventing spoilage using without using preservatives. So this aluminium plays a crucial role here, so it is also, it permeability to light and oxygen is very low. Also it removes the need for the refrigeration and it also prevents the spoilage microorganisms.

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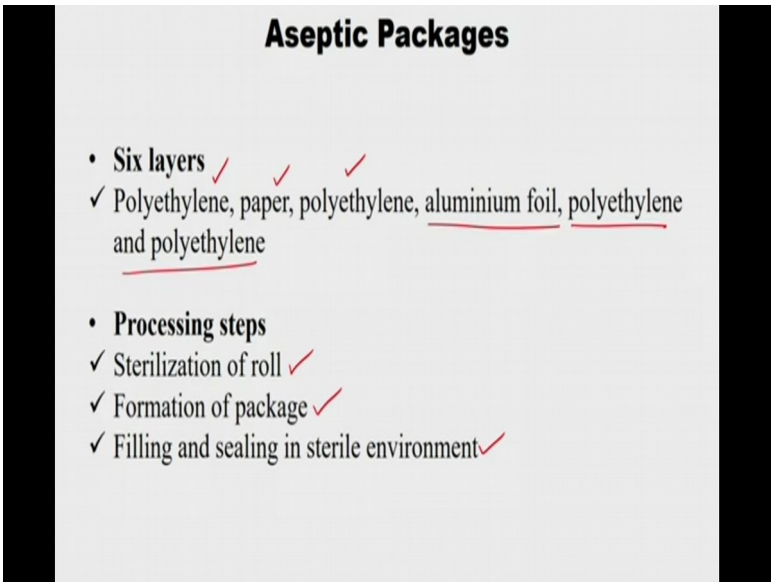

So the 6 layers are normally being done using these three combinations. First one is polyethylene, then paper, then polyethylene, polyethylene is outside to make it dry, then paper gives the structure, then again polyethylene, then aluminium foil. So. then after that polyethylene and polyethylene package. So 6 times these layers are repeated and processing steps we already told. First sterilization of the roll, then formation of the packaging and filling and sealing in the sterile environment. So this is for packaging. For packaging first we sterilize the roll, then we forms the package, then after the the food product is sterile then it is filled and sealed in the sterile environment.

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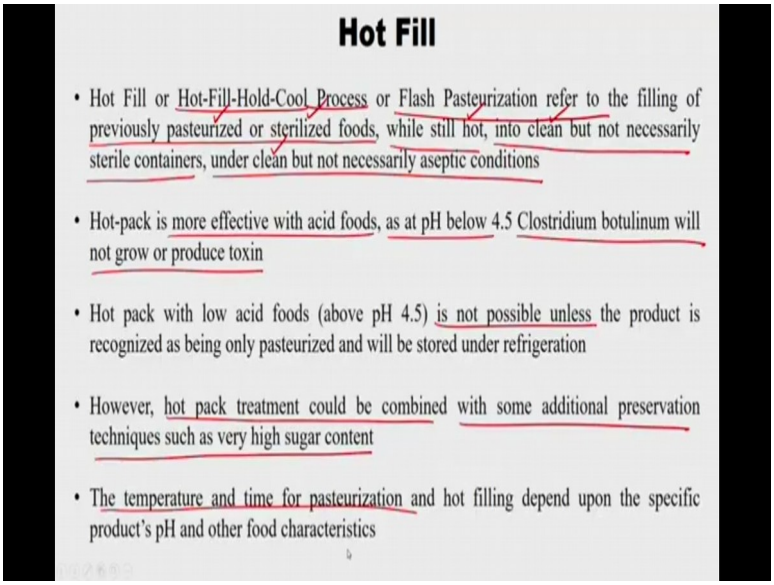

So the next one is hot fill. Hot fill or hot-fill-hold-cool process or flash pasteurization so everything refers to hot fill only. Actually this is previously pasteurized food or sterilized foods while still in hot condition in to the clean but not necessarily sterile containers under clean but not necessarily aseptic conditions. So what is the difference between UHT or aseptic process and hot fill is, so here the filling of already pasteurized or sterilized food. There it is in UHT it is only sterilized food but here either pasteurized or sterilized food is find and it is filled in hot condition in to a clean packaging, clean container but not in sterile container, it in clean environment but not in sterile environment.

So already sterile or pasteurized food so there itself we had some compensation and it is in still hot condition into a clean container but not in sterile container. The same with clean environment but not in sterile environments. So hot pack is most effective with acid foods set pH below 4 point 5. The Clostridium botulinum already we told, the C.bot will not grow in that condition. Hot pack with low acid foods is not possible because we are already told we are not maintaining the steriled food products because it is also applicable for pasteurized food.

However, hot pack treatment could be combined with some additional preservation techniques such as very high sugar content. So since we are not maintaining the sterile food and sterile condition and sterile containers so it has to be stored in refrigeration environment and also sometimes if it is not then we need to use preservatives or it has to be stored in the refrigeration

conditions. So the time temperature combination for pasteurization and hot filling depend upon the specific product pH and food characteristics.

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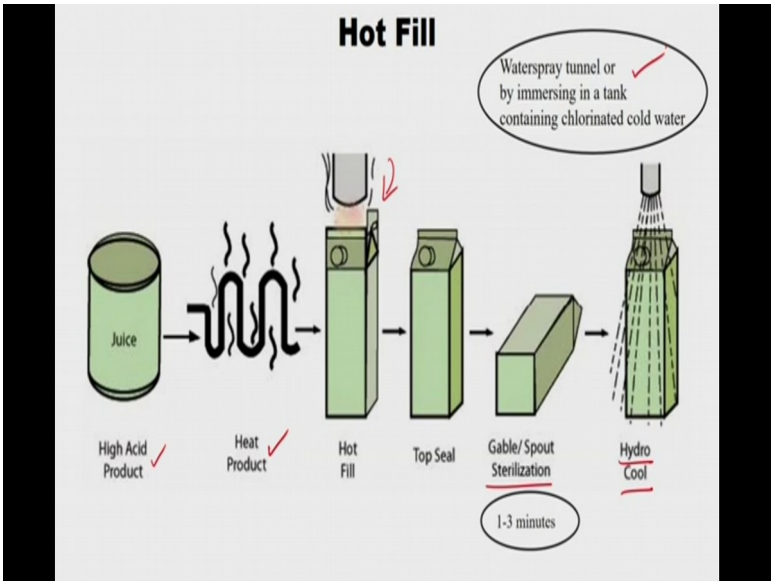

So this is normal hot fill. So you have a high acid product. So this is we supposed to heat the product then it is filled in the hot condition. The container need not be a sterile container but should be clean one then we have to top seal it. Then we sterile it for 1 to 3 minutes after the hot fill is done and then we use hydro cool. So, usually water spray tunnel we use or we immerse the tank containing chlorinated cold water. Why chlorinated water, we have discussed in the blanching itself.

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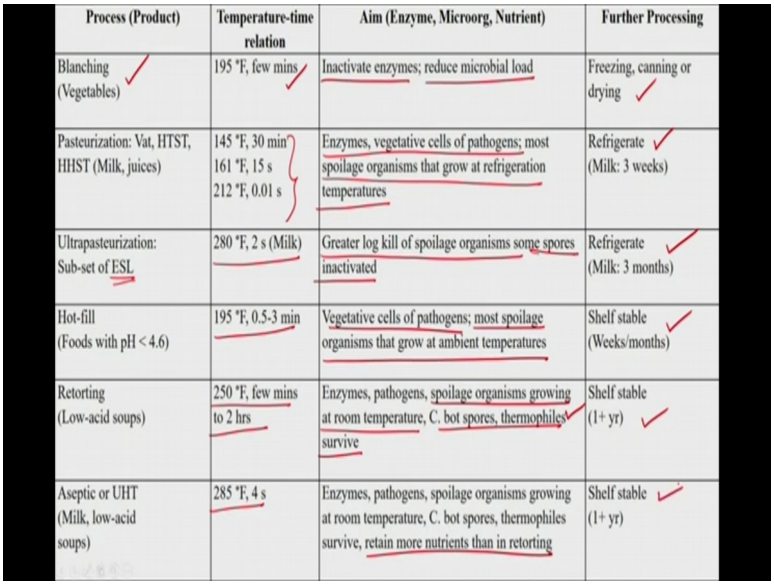

Process (Product)	Temperature-time relation	Aim (Enzyme, Microorg, Nutrient)	Further Processing
Blanching (Vegetables)	195 °F, few mins	Inactivate enzymes; reduce microbial load	Freezing, canning or drying
Pasteurization: Vat, HTST, HHST (Milk, juices)	145 °F, 30 min 161 °F, 15 s 212 °F, 0.01 s	Enzymes, vegetative cells of pathogens; most spoilage organisms that grow at refrigeration temperatures	Refrigerate (Milk: 3 weeks)
Ultrapasteurization: Sub-set of ESL	280 °F, 2 s (Milk)	Greater log kill of spoilage organisms some spores inactivated	Refrigerate (Milk: 3 months)
Hot-fill (Foods with pH < 4.6)	195 °F, 0.5-3 min	Vegetative cells of pathogens; most spoilage organisms that grow at ambient temperatures	Shelf stable (Weeks/months)
Retorting (Low-acid soups)	250 °F, few mins to 2 hrs	Enzymes, pathogens, spoilage organisms growing at room temperature, C. bot spores, thermophiles survive	Shelf stable (1+ yr)
Aseptic or UHT (Milk, low-acid soups)	285 °F, 4 s	Enzymes, pathogens, spoilage organisms growing at room temperature, C. bot spores, thermophiles survive, retain more nutrients than in retorting	Shelf stable (1+ yr)

So this is overview of that. So blanching is done with 195 degree Fahrenheit for few minutes. So it inactivates enzymes reduce microbial load but the further processing is freezing, canning or drying. Pasteurization, it can be of any type, the time temperature combination is given at it enzymes inactivate and vegetative cells of pathogens most spoilage organisms that grows at refrigeration temperature and further processing it has to be refrigerated. So if we use as ultra-pasteurization, it is a subset of extended shelf life. So the time temperature combination is given for milk so it kills the greater log kill of spoilage microorganisms compared to normal pasteurization.

Some spores also inactivated. It also has to be refrigerated. Then next one is hot-fill so that time temperature combination is given. The vegetative cells of pathogens can be killed most spoilage organisms that grow at ambient temperature also killed and shelf stable weeks and months and retorting this is nothing but a sterilized right sterilization. So with the time temperature combination is given and since pathogen, spoilage of organisms growing at room temperature, C.bot everything can be killed but thermophiles survives, shelf stable it is 1 plus year and aseptic or ultra-high temperature.

So the time temperature combination is given and here it everything what is does in retorting but also it retain more nutrients in retorting. So this is also shelf stable. So these three are shelf stable, one is a AHT or UHT, retorting and hot fill. Hot fill we cannot remove the C.bot. Low

acid food it cannot be used because we did not maintain the sterile environment and but for retorting it also kills the C.bot spores but thermophiles still survive but if we use ultra high temperature we can maintain the nutrient quality that cannot be done in retorting. The pasteurization, blanching, ultra pasteurization already discussed.

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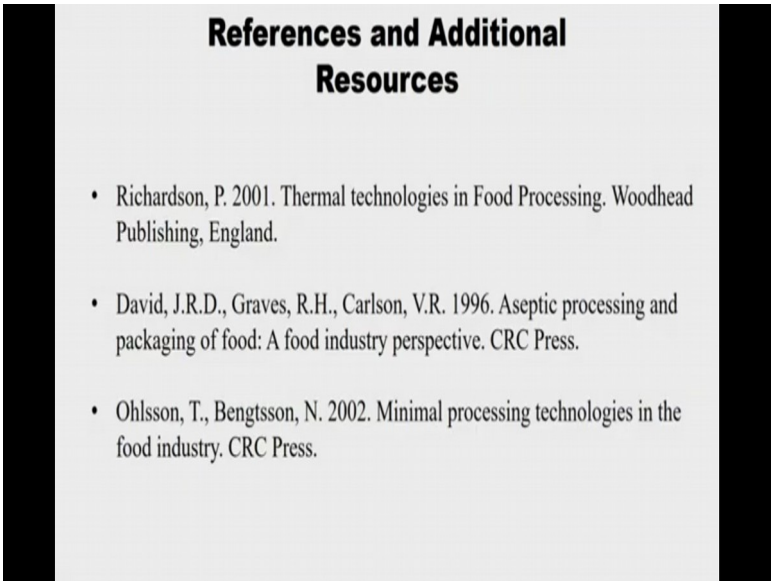

So these are reference and additional resources. Thank you.